

USARIEM TECHNICAL REPORT T01-15

**SIT-UP RELATED INJURIES REPORTED TO THE
U.S. ARMY SAFETY CENTER, 1980-1998:
A CASE SERIES**

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August 2001

U.S. Army Research Institute of Environmental Medicine
Natick, MA 01760-5007

20010820 049

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
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1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE August 2001		3. REPORT TYPE AND DATES COVERED Technical Report
4. TITLE AND SUBTITLE Sit-up Related Injuries Reported to the U.S. Army Safety Center, 1980-1998: A Case Series			5. FUNDING NUMBERS	
6. AUTHOR(S) G.A. Schneider, L. Senier, R. Evans, C. Scoville, P.J. Amoroso				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Army Research Institute of Environmental Medicine Natick, Massachusetts 01760-5007			8. PERFORMING ORGANIZATION REPORT NUMBER T01-15	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Medical Research and Materiel Command Fort Detrick Frederick, MD 21702-5012			10. SPONSORING / MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) The Army Physical Fitness Test (APFT) is a three-event test including timed sit-up and push-up tests and a 2-mile timed run. Anecdotal reports suggesting that the sit-up event may contribute to back or neck injury led to this investigation of the only known historical data on sit-up related injuries. This case series analysis describes all sit-up related injuries among active duty soldiers that occurred between 1980 and 1998 and were reported to the US Army Safety Center (N=57). Of these, 86% occurred to young men, 88% occurred on duty, and 98% occurred on a military installation. Approximately 80% of the injuries affected the back or neck. Nearly half occurred during the APFT (44%), and approximately 75% of the soldiers who sustained sit-up related injuries experienced an immediate onset of symptoms. Twelve percent of the soldiers in our case series who experienced a sit-up related injury also had a prior injury, most typically of the back, neck, or shoulder. Notwithstanding the limitations of these data, this report confirms what is known in a general sense about sit-up related injuries and offers direction for further research.				
14. SUBJECT TERMS injury, Army, TAIHOD, U.S. Army Safety Center, military personnel, case series, sit up, Army Physical Fitness Test, APFT			15. NUMBER OF PAGES 22	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT UL	

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ACKNOWLEDGMENTS

The authors would like to thank the following individuals for their assistance in preparing this technical report:

Edward Heffernan, U.S. Army Safety Center, and Mary Ann Thompson, MA, Engineering Research Psychologist, ORSA Division, U.S. Army Safety Center, and Joseph Knapik, ScD, MAJ (ret), U.S. Army Center for Health Promotion and Preventive Medicine, for their insightful comments on the draft manuscript.

Ana Rosas for assistance in assembling and formatting the report, and Shari Hallas for editing the text.

EXECUTIVE SUMMARY

Soldiers must maintain a high level of fitness in order to meet a worldwide mission of defending the United States from its enemies. The Army evaluates soldier physical fitness semiannually via the Army Physical Fitness Test (APFT), a three-event performance assessment that produces an objective measure of a soldier's cardiovascular fitness and upper- and lower-body muscular endurance. The APFT currently comprises timed push-up and sit-up tests and a 2-mile timed run. Although the APFT has stood the test of time, questions are occasionally raised about the safety and efficacy of the individual test events. In particular, concerns have surfaced recently that the sit-up event may be placing soldiers at risk of back or neck injuries. As the U.S. Army is the only branch of the military services that still requires soldiers to perform sit-ups (i.e., hands behind the head while moving the trunk up from the ground) rather than curl-ups or crunches, it is appropriate to review what is known about risk of sit-up related injury.

This report draws upon a data source that has not been fully utilized in the epidemiologic study of training-related injuries. The U.S. Army Safety Center's Army Safety Management Information System (ASMIS) database collects data on injuries that result in death, hospitalization, lost time from work, and/or extensive property damage. Although it is not intended to capture information on all injuries (e.g., intentional injuries and battle-related injuries are not included) and under-reporting is believed to be significant, the Safety Center does capture information on a fairly representative subset of injuries experienced by Army soldiers. Safety Center reports comprise two elements: a coded report with a wide range of variables, and narrative reports containing textual accounts of the circumstances of the injury event. This report analyzed narrative accounts of the sit-up related injuries that occurred between 1980 and 1998 and were reported to the Safety Center, as a qualitative exercise to explore possible risk factors for sit-up related injury and to identify research objectives for future studies.

In this review, we performed an automated text search of the Safety Center narrative reports to locate all accounts that included the word or words "sit-up," "situp," or "sit up." This search identified 57 such injuries that occurred to active-duty Army soldiers between 1980 and 1998; 86% occurred to young men, 88% occurred while the soldier was on duty, and 98% occurred on a military installation. These injuries were associated with measurable financial costs and lost duty days; the median cost of such injuries was \$1,570, and the median number of lost duty days was 3. Approximately 80% of these injuries affected the back or neck. Nearly half of these injuries occurred during the APFT (44%), and approximately 75% of the soldiers who sustained sit-up related injuries, as documented in these reports, experienced an immediate onset of symptoms. Twelve percent of the soldiers in our case series who experienced a sit-up related injury also had a prior injury, with injuries to the back, neck, or shoulder predominating.

This report has several limitations that should be noted. First, it is probable that not all sit-up related injuries have been reported to the Safety Center. If we assume that soldiers perform sit-ups on a regular basis to maintain fitness and prepare for the APFT,

the number of sit-up related injuries occurring during the APFT should be small relative to the number of all sit-ups performed during an entire year. This may not hold true, however, if soldiers are not practicing under the same time limitations they will face in testing. If soldiers are practicing at their leisure, when they may be more attuned to maintaining proper form, but then hurrying to perform the maximum number of repetitions during the 2-minute timed test, they may be more likely to sacrifice proper form during testing, and thus open themselves to risk of injury during testing. The fact that the proportion of injuries during the APFT in this case series was as high as it was (43.9%) increases our suspicion that this is indeed occurring. Although the likelihood of under-reporting may render the quantitative findings in this report suspect, our findings suggest that the format of the APFT should be examined with regard to how it might influence risk of sit-up related injury. On the other hand, the scope of this problem is in question. Some 500,000 soldiers take the APFT twice a year; if the sit-up event on the APFT posed a serious threat to soldier health, one might expect reports of injuries to be more common than our search has demonstrated. More rigorous research is needed to explore this question definitively.

Apart from the problem of under-reporting, this case series did not assess injuries that may have occurred during other APFT events, and so could neither assess the safety of those events or whether they may interact to place soldiers at risk of injury. This case series also included only acute injuries associated with the performance of sit-ups; it could not assess the cumulative impact the performance of sit-ups may have on a soldier's overall health.

These limitations, taken together, make it difficult to draw firm, objective conclusions about the association of sit-ups and injury. This report does, however, confirm what is known in a general sense about such injuries (especially, for example, that they are likely to occur to the back and neck) and suggests the need for future research. More studies are needed to assess the risk of injuries, both acute and chronic, during the APFT. Risk factor identification will be enhanced through the collection of more detailed information on demographic characteristics, health-risk behaviors, and typical training practices. Finally, studies are needed to document more fully the costs associated with training injuries that may be associated with any of the APFT events.

INTRODUCTION

Soldiers must maintain a high standard of physical fitness in order to meet a worldwide mission of defending the United States from its enemies. Army regulations require soldiers to participate in year-round physical fitness training programs in order to maintain an appropriate level of fitness. The Army Physical Fitness Test (APFT) is a simple, three-event physical performance test that produces an objective measure of a soldier's cardiovascular fitness and upper and lower body muscular endurance (11-13). Regulations explicitly state, however, that the APFT is only one assessment of soldier fitness, and that a training program geared toward attainment of a particular score on the APFT is an inadequate strategy for meeting the goal of total Army fitness. Moreover, balancing the need for high levels of fitness while minimizing risk of injury has proven difficult.

While the APFT undeniably has its virtues (it is a simple series of activities that requires no equipment and minimal training and can be performed virtually anywhere in the world), questions are occasionally raised about the safety and efficacy of the individual test events. Specifically, there have been anecdotal reports of back or neck injuries incurred during the sit-up event of the APFT. Abdominal strength and endurance are assessed during the APFT through timed performance of the full sit-up (maximum number of repetitions in a 2-minute period) (11, 12). While studies support the use of the sit-up as an exercise to assess and improve abdominal strength (4, 5, 16, 21, 27), concerns have been raised about the potential for back and neck injury due to use of the full sit-up as a training and testing tool. Acute back and neck injuries incurred while performing sit-ups have also been reported and are hypothesized to result from performing the sit-up incorrectly, or when continuing the exercise after the abdominal muscles have become fatigued (17). Even when performed correctly, however, it is hypothesized that degeneration will occur progressively when the spine is subjected to high forces through a large range of motion on a repetitive basis (23), as may occur when full sit-ups are performed habitually. It is beyond the scope of this report to assess the cumulative impact on an individual's risk of back and neck injury, such as may result from a lifetime of performing sit-ups of the sort required by the APFT. The acute risks of injury associated with performing sit-ups are not well understood, however, and it is this issue we propose to examine more closely.

Because none of the large administrative databases that exist at an Army-wide level contain variables with sufficient specificity to identify and describe such injuries, we conducted a systematic review of the only database known to provide at least minimal detail on such injuries: the U.S. Army Safety Management Information System (ASMIS) database. The purpose of this report is to *qualitatively* assess the injury cases captured in ASMIS as being caused by or occurring during the act of performing sit-ups. This qualitative analysis can suggest hypotheses about possible risk factors for injury that may be associated with the sit-up event on the APFT, and will suggest questions that deserve more rigorous research inquiry.

BACKGROUND

The APFT has been used in its present form since 1981 (7). The test comprises three events: push-ups, sit-ups, and a 2-mile timed run, to be performed in that order and on the same day (11, 13). The text of Army Field Manual 21-20 detailing the sit-up event appears in Appendix A; the APFT scorecard (DA Form 705) is shown in Appendix B. All active-duty Army soldiers and all full-time members of the Army National Guard and Army Reserve are required to take the APFT semiannually, regardless of their age (11, 13).

Performance on the APFT is used as a measure of the soldier's fitness level and the ability to perform fitness-related tasks (12). While the APFT test is an important tool in determining the physical readiness of individual soldiers and units, and in allowing objective comparisons among units and individuals, it is not intended to be the sole basis for a unit's physical fitness training program (11, 12). Commanders often do, however, use their unit's APFT results to evaluate the unit's overall physical fitness level. Substandard APFT results may indicate a need to modify unit or individual fitness programs to attain higher fitness levels. The lowest passing APFT scores are intended to reflect the minimum acceptable fitness level for all soldiers, regardless of Military Occupational Specialty (MOS) or component. Service schools, agencies, and specialized units may set performance goals that are above the minimum APFT standards in accordance with their missions (11-13). Individuals can use results to evaluate their own performance over time and against an objective Army-wide standard. Individual soldiers are also encouraged to set for themselves a series of successively higher APFT performance goals. Finally, APFT scores figure in the determination of promotion points for enlisted personnel. This incentive may motivate some soldiers to overexert themselves during the APFT.

Each of the armed services has a different method of assessing physical fitness. The Air Force requires an annual submaximal cycle ergometry test in which members pedal on a stationary bicycle at a controlled pace (9). Recent changes to Air Force regulations will soon require airmen to perform push-up and sit-up tests as well (20). In contrast to the Army regulations, Air Force participants will have 1 minute to perform the prescribed number of push-ups and sit-ups, and will perform these tests after the aerobic event (20). Execution of the sit-up will also differ, as the subject will fold the arms over the chest and curl-up until the elbows touch the thighs or knees. The Navy assesses physical readiness semiannually, by a 1.5-mile run, a 2-minute push-up test, and a 2-minute curl-up test. To perform the curl-up, sailors lie flat on their backs with their feet flat on the floor and, with arms folded over their torsos, curl up until their elbows touch their thighs (14). The Marine Corps Physical Fitness test is a semiannual test with different activities and scoring structures for men and women. The Marines assess upper body strength among men via a pull-up test, whereas women perform a flexed-arm hang test (29). Both men and women perform a 3-mile timed run and a sit-up test (maximum number of sit-ups performed within 2 minutes, with feet flat on the floor and arms folded over the chest) (29). The Air Force, Marines, and Navy thus require their servicemembers to perform curled-trunk sit-ups with the arms crossed over the chest as part of their physical readiness testing. As the only service that continues

to use the full sit-up with the hands placed behind the head as a component of the APFT, the Army has come under some pressure to justify the practice, especially in the face of anecdotal, although thus far unsubstantiated, reports of injuries caused by sit-ups.

SIT-UPS AND INJURY

Abdominal strength is an important component of overall fitness. Abdominal muscles function with the muscles of the lower back to stabilize the spine and pelvis. Weak abdominal musculature is associated with an increased lordosis of the lumbar spine, which compresses the posterior elements and increases the shear forces on the lumbar discs (22). Abdominal strengthening exercises are recommended to prevent low back pain and improve function (1, 6, 28) and are a component of most fitness programs.

Because of the importance of abdominal strength in overall fitness, a number of tests have been developed to assess abdominal muscle strength (15, 19, 27). The full sit-up test is often used in physical fitness programs, including that of the U.S. Army, because it is a reproducible measure with a specific start point and end point, and it can be performed and evaluated with minimal training and no equipment virtually anywhere in the world (31).

While the benefits of sit-ups to fitness training and assessment are well understood, concerns that they may cause injury, especially to the neck and spine, are well grounded on a theoretical basis (23). If the abdominal muscles fatigue in the performance of the exercise, the risk of injury becomes most significant (17). The completion of a full sit-up involves both abdominal and hip flexor muscles. The abdominal muscles initiate the curl-up activity and stabilize the lumbar spine, while the hip flexors are responsible for flexing the pelvis and fixed lumbar spine into the full sit-up position (17). If the abdominal muscles are weak or become fatigued, the spine may assume a hyperextended position. The hip flexors, in particular the psoas muscle, may then pull at the lumbar spine, creating anterior shear forces on the spine that increase pressure on the intervertebral discs (22, 26).

Proper execution of the sit-up is important. To adequately assess abdominal muscle strength, the participant must curl the trunk up to initiate the sit-up; otherwise, the hip flexors are exerting most of the work (4). In her classic text, *Muscles: Testing and Function*, Florence Kendall states, "The problem with using the sit-up movement as a test . . . lies in the failure to differentiate between a 'curled-trunk' sit-up and an 'arched-back' sit-up. For accurate testing of abdominal muscle strength, the test must be done slowly, making sure (a) that the trunk curls before hip flexion starts, and (b) that the curl is maintained when hip flexion starts and while moving to the sitting position (17)."

Additional mechanics that place a sit-up subject at highest risk for injury are performing the sit-up with the hands behind the head, keeping the legs straight, having the feet secured, holding the breath, or allowing the lumbar area to lift off the mat (19).

The APFT in its current form requires the soldier to lift the lumbar area off the mat with the feet secured and hands interlocked behind the head.

When executed properly and limited in time and number, the sit-up is not likely to result in injury (17). The test as performed in the APFT does, however, require speed of performance and repetition of the activity as many times as possible over a 2-minute period, and makes exercise to fatigue a virtual certainty. It can thus be expected that risk of injury will be greater during testing than during training, especially among those soldiers who do not perform sit-ups as part of their routine physical training program.

While the sit-up is a high muscle-challenge abdominal exercise, it is also a high compression exercise, and thus may have a higher potential for compressive-type injuries to the spinal column than other abdominal exercises (5). It may also have a less effective endurance component than the curl-up (25). A Canadian study of 9 male civilian volunteers sought to determine whether any particular form of abdominal exercise would optimize abdominal activation but minimize compressive loads on the lumbar spine (5). They compared twelve different forms of sit-up exercises (e.g., straight-leg or bent-leg sit-up versus partial curls or "crunches"), and for each type of exercise, calculated a cost index of abdominal challenge to spinal compression. They found that no single exercise was sufficient to optimally train all of the abdominal muscles while minimizing intervertebral joint loads. They ultimately concluded that a variety of abdominal exercises are required to sufficiently challenge all of the abdominal muscles.

Civilian and military studies demonstrate that poor performance on sit-up tests is associated with increased risk of injury. In a cohort of male infantry soldiers followed prospectively for 1 year, Reynolds et al. found that soldiers who performed the fewest sit-ups (i.e., the lowest quintile) were at twice the risk of lower extremity and low-back musculoskeletal training injuries compared to soldiers in the second-highest quintile of sit-up performance (24). Similarly, Knapik et al. followed a cohort of male soldiers in an infantry battalion in Alaska and found that soldiers performing in the lowest quartile on the sit-up test were significantly more likely (1.9 times more likely) to sustain an injury, compared to those soldiers in the quartile performing the most repetitions on the sit-up test (18). Low number of repetitions in the sit-up test has also been reported to be a major risk factor for back injury in nurses (30).

METHODS

The Total Army Injury and Health Outcomes Database (TAIHOD) (2, 3) joins key elements from multiple Department of Defense (DoD) administrative, health, and safety databases, linked at the individual soldier level by encrypted Social Security Numbers. This study reviewed reports of injuries to active-duty Army soldiers that occurred between 1980 and 1997 and were reported to the Safety Center and captured in the ASMIS database.

One of the missions of the Safety Center is to document unintentional injuries resulting in death, hospitalization, lost time from work, or extensive property damage (8,

32). Intentional injuries (e.g., homicide and suicide) and battle-related injuries are not included, nor are injuries that result in no lost time from work if the accident does not involve other injuries or property damage (even if treated in a military medical treatment facility on an outpatient basis). Reports sent to the Safety Center on accidents and injuries are not all-inclusive, especially for nonfatal injuries, for two reasons. First, not all injuries meet the defined criteria for reporting (10) and second, under-reporting is widespread, with only approximately 15% of eligible hospitalized cases being reported to the Safety Center. However, despite considerable under-reporting, there is little current evidence that those cases that are reported are systematically biased and, therefore should be representative of the total injury morbidity for the Army. Moreover, the details available in Safety Center reports regarding cause and activity are unmatched in any other Army medical or administrative database and render this data source uniquely useful in epidemiologic research.

ASMIS records contained in the TAIHOD comprise two separate components: narratives describing the circumstances under which the event occurred, and coded reports containing standardized information collected on all reported accidents. The principal and primary source of these narrative and coded reports is DA Forms 285 and 285-AB (see Appendix C). Form 285 is the full form and is required for serious injuries; Form 285-AB is an abbreviated form and is typically used for lost workday cases (of the sort reported in this study). These forms are typically completed by a representative of the injured soldier's unit or occasionally by a local safety office representative. The narrative reports may be as long as several pages or as short as several sentences; the level of detail is dependent upon the severity of the injury and is largely left up to the discretion of the individual completing the form. Serious cases (especially those where a death occurred) almost always include a much greater level of detail than other cases, sometimes with several pages of accompanying text. Sample narrative accounts of some of the sit-up related injuries included in this case series appear in Appendix D.

The Safety Center defines lost-duty days as full 24-hour periods when the servicemember could not perform his or her duty because of injury or illness. This does not include, therefore, the day of onset of the injury or illness or days when the servicemember would not be required to be at work (e.g., weekends or holidays)(10). Nonfatal injuries or illnesses that result in restricted duty, light duty, or profile days are captured in ASMIS only if they also involve property damage. ASMIS includes some information on cost of illness or injury, but actual costs associated with provision of medical care or lost duty days is often not known at the time the report is filed (10). The injury cost information supplied in the report is thus an estimate and not actual cost.

VARIABLES FOR ANALYSIS

For our analyses, we searched all injury cases occurring between 1980 and 1997 that were reported to the Safety Center. To be selected for further evaluation, one of

* P.J. Amoroso. Total Army Injury and Health Outcomes Database Overview, Briefing to the Joint Operational Readiness Management Team, Joint Safety Chiefs Meeting, U.S. Army Safety Center, Ft. Rucker, AL, 27 June 2000.

the narrative fields for the case had to include the word or words "sit-up," "situp," or "sit up" in the Sequence of Events, Task Error, or Why Mistake Made text fields. These search terms resulted in retrieval of plural forms of these terms as well. The narrative accounts of these cases were then manually reviewed to determine if the injury in question was indeed the result of performing sit-ups.

One hundred nineteen (N=119) cases were identified that had the word or words "sit-up," "situp," or "sit up" in the Sequence of Events, Task Error, or Why Mistake Made text fields and also had a matching coded Safety Center record. Upon review of the full text narratives, 57 (47.9%) of these were identified as being sit-up related and were retained for further analysis.

Three new variables were created in order to record the additional information extracted from the narratives. First, was the injury directly associated with the physical fitness test itself (APFT)? Second, did the symptoms associated with the injury manifest themselves immediately or were they delayed in onset (ONSET)? Third, was a prior injury/condition associated with the injury (PRIOR)? These indicator variables were coded as yes, no, or unknown.

Because narrative data associated with Safety Center reports in the TAIHOD are maintained in a different format from the coded reports, the variables created and subsequently coded by review of the narrative fields (APFT, ONSET, and PRIOR) had to be linked to the coded data for the selected cases. The distribution of gender, duty status, body-part injured, injury diagnosis, lost duty days, and injury costs are reported for only the subset of cases with coded Safety Center reports.

ANALYTIC APPROACH

Frequencies and percentages of gender, duty status (i.e., on- versus off-duty), location where the injury occurred (i.e., on- versus off-post), body part affected, diagnosis, and cause of injury were calculated. Measures of central tendency are presented for lost workdays, days hospitalized, and cost of injury. Frequencies and percents for the variables originating from the narratives APFT, ONSET, and PRIOR are presented.

All analyses were conducted in either SAS version 8.01 (SAS Institute, Cary, NC) or STATA version 6.0 (STATA Corporation, College Station, TX). The analyses conducted herein adhere to the policies for protection of human subjects as prescribed in Army Regulation 70-25 and with the provisions of 45 CFR 46.

RESULTS

Table 1 presents descriptive statistics regarding the 57 sit-up related injuries that occurred to active duty soldiers between 1980 and 1998 and were reported to the Safety Center. Of these, the vast majority occurred to male soldiers (N=49). These injuries predominately occurred while on duty (N=50) and while on a military post (N=56).

Table 1. Sit-Up Related Injuries Among Active-Duty Army Soldiers Occurring Between 1980 and 1998 and Reported to the U.S. Army Safety Center (N=57)

	N	%
Male	49	86.00%
On duty	50	87.70%
On post	56	98.25%

Table 2 shows that the average number of estimated days lost and days hospitalized due to these 57 injuries was 9.8 and 2.7 days, respectively, while the mean estimated monetary cost was \$4,733.09. These measures, however, are skewed heavily by the most severe and costly injuries, as the median measures are 3.0 days, 0 days, and \$1,570.00, respectively. It should be noted that in all cases where no lost duty days were recorded (value of 0), the days hospitalized were greater than 0, and vice-versa. Furthermore, in all cases where both of these measures had a value greater than 0, the value of the days hospitalized was never greater than the value of the lost duty days. A more accurate summary measure of the lost days due to sit-up related injuries in this sample was calculated by using the greater of the lost duty days and the days hospitalized values for each subject. It is important to note that these summary measures are estimates and do not necessarily represent exact costs; however, they do provide some evidence of the potential cost of such injuries.

Table 2. Lost Duty Days and Costs Associated with Sit-Up Related Injuries Among Active-Duty Army Soldiers Occurring Between 1980 and 1998 and Reported to the U.S. Army Safety Center (N=57)

	Mean	Median	Min	Max
Lost duty days	9.8	3	0	90
Days hospitalized	2.7	0	0	21
Greater of lost duty days or days hospitalized	10.3	4	1	90
Cost	\$4,733	\$1,655	\$120	\$37,960

Table 3 presents information regarding the body part affected, diagnosis, and cause of injury associated with these injuries as documented in Safety Center coded reports. For this analysis, only the primary diagnoses were recorded. The back and neck were the two most common body regions injured, accounting for 36 (63.2%) and 10 (17.5%) injuries, respectively. There were an additional 3 (5.3%) injuries to the trunk/abdominal region, 3 to the head, and 2 (3.5%) each to the shoulder and arm. There was 1 injury case coded as a knee injury; however, review of the narrative account of this injury revealed that it was in fact a neck injury and was therefore more appropriately placed in that category. Twenty-seven (N=27) of these injuries were diagnosed as sprains, while "other" was the second most common injury type code (N=17). Fractures (N=4), hernias (N=3), dislocations (N=2), and concussions (N=1) accounted for the other injury diagnoses. The most prevalent cause-of-injury codes were bodily reaction (N=29) and overexertion (N=20). The 3 head injuries were coded

as struck against (N=2) and fell from elevation (N=1). One injury was coded as an unknown cause.

Table 3. Body Part Affected, Primary Diagnoses, and Cause of Injury in Sit-Up Related Injuries Among Active-Duty Soldiers Occurring Between 1980 and 1998 and Reported to the U.S. Army Safety Center

		N	%
Body Part	Back	36	63.2%
	Neck	10	17.5%
	Head	3	5.3%
	Trunk	3	5.3%
	Shoulder	2	3.5%
	Arm	2	3.5%
	Other	1	1.8%
Diagnosis	Sprain	27	47.4%
	Other	17	29.8%
	Fracture	4	7.0%
	Hernia	3	5.3%
	Dislocation	2	3.5%
	Concussion	1	1.8%
	Missing or other	3	5.3%
Cause	Bodily reaction	29	50.9%
	Overexertion	20	35.1%
	Struck against	2	3.5%
	Fell from elevation	1	1.8%
	Unknown	1	1.8%
	Missing or other	4	7.0%

Table 4 presents descriptive statistics for the indicator variables APFT, ONSET, and PRIOR. Of the 57 sit-up related injuries, 25 (43.9%) occurred during the APFT, 43 (75.4%) had an immediate onset of associated symptoms (ONSET), and 7 (12.3%) had prior injuries/conditions (PRIOR) that were attributed to causing the injury.

Table 4. Circumstances Surrounding Sit-Up Related Injuries among Active Duty Soldiers Occurring Between 1980 and 1998 and Reported to the U.S. Army Safety Center (N=57)

	N (%)
During APFT	43.9% (n=25)
Immediate ONSET	75.4% (n=43)
PRIOR Injury	12.3% (n=7)

DISCUSSION

This report reviews injuries associated with sit-ups occurring between 1980 and 1998 as reported to the Safety Center. As stated earlier, not all injuries are reported to the Safety Center. In spite of this under-reporting, the Safety Center narratives contain

detailed information about the injuries that *are* reported. Our qualitative analyses of these reports confirm, in a general way, what is known about risk of injury that may be associated with sit-ups, but also suggest some hypotheses that require more rigorous research.

Male soldiers accounted for the larger proportion of sit-up related injuries; this simply reflects the demographic distribution of men and women in the Army. Given what is known about the biomechanics of sit-ups and injury, the distribution of body part affected, associated diagnosis, and cause of injury among the soldiers with sit-up related injuries is perhaps not surprising. The predominance of injuries to the back and neck would be expected, as these are the anatomical regions that are subjected to the greatest musculoskeletal stressors in the performance of the full sit-up. The common occurrence of the cause-of-injury codes of bodily reaction and overexertion are consistent with the most common diagnostic codes of sprain and other, the latter of which is often used as a blanket diagnostic code for unspecified pain or general overuse injury.

The accounts of sit-up related injuries that were reported to the Safety Center also reveal that the vast majority occurred while on duty (87.7%) and on a military installation (98.3%). This finding should be interpreted cautiously, as there is a strong likelihood of reporting bias. Army regulations explicitly state that commanders are to give soldiers duty time (up to 3 hours per week) toward physical training, in order that they might maintain an appropriate level of fitness (11, 12). Since active-duty soldiers are allowed to use duty time toward the maintenance of a fitness regimen, any sit-up related injuries that occur to them in the pursuit of that fitness regimen would probably be deemed duty-related.

In any event, if we assume that soldiers perform sit-ups on a regular basis to maintain fitness and prepare for the APFT, the number of sit-up related injuries occurring during the APFT should be small relative to the number of all sit-ups performed during an entire year. This may not hold true, however, if soldiers are not practicing under the same time limitations they face in testing. If soldiers are practicing at their leisure, when they may be more attuned to maintaining proper form, but then hurrying to perform the maximum number of repetitions during the 2-minute timed test, they may be more likely to sacrifice proper form during testing, and thus open themselves to risk of injury during testing. As described previously, performing the full sit-up past the point of fatigue probably increases the risk of injury. The fact that the proportion of injuries during the APFT in this case series was as high as it was (43.9%) increases our suspicion that this is indeed occurring. Although the under-reporting may render the quantitative findings in this report suspect, our findings suggest that the format of the APFT should be examined with regard to how it might influence risk of sit-up related injury. On the other hand, the scope of this problem is in question. Some 500,000 soldiers take the APFT twice a year; if the sit-up event on the APFT posed a serious threat to soldier health, one might expect reports of injuries to be more common than our search has demonstrated. More rigorous research is needed to explore this question definitively.

The finding that prior injuries or pre-existing conditions appear to be influential in the development of sit-up related injuries is potentially of great interest. Specifically, of the 7 instances where prior injury was a contributing factor, 6 (85.7%) occurred to the neck, shoulder, and arms. Prior injury was suggested as a factor in 40% of all the neck injuries, and 50% of all shoulder and arm injuries, respectively. This might suggest that individuals with prior injuries to these body regions should perhaps not perform sit-ups, and might demonstrate abdominal strength through an alternative and safer method.

An important limitation of this study is that it did not assess injuries that may have been related to other APFT events: the push-ups and the 2-mile run. Several of the narratives we reviewed suggested that a soldier could not complete the run because of back pain, or completed all of the events but later complained of pain or injury, and it was not possible to determine which event it might have been associated with. Future studies should examine the possibility that overexertion in one event may increase risk of injury in another event. Another limitation of this study is that it assessed only the association of acute injury with the performance of sit-ups. Even when performed correctly, sit-ups of the sort required by the APFT may place a person at risk of chronic injury or disability. To evaluate this, a prospective study that gathers information on frequency and intensity of training would be needed.

RECOMMENDATIONS FOR FUTURE RESEARCH

Military personnel are, of necessity, continually subjected to repetitive motions, which are known to contribute to both acute and chronic injury (e.g., fixed postures, heavy and repetitive lifting, marching with large loads, whole-body vibration). Repetitive activities that do not provide sufficient benefit when compared with the cost should be scrutinized.

The findings presented here should not be over-interpreted, given the significant limitations of these data. However, they do provide a starting point that defines a need for more research to assure that APFT testing is helping, not hurting, military readiness. Research is needed that supports or refutes the role of the APFT test events as they relate to performance of military tasks, military readiness, and overall health and fitness. Additionally, studies are recommended that assess how training and testing for APFT events may impact acute injury, chronic injury, and disability.

The following is a list of recommended research objectives to address in future studies:

- a. Assess acute injury incidence during the APFT, and assess impact of these injuries on military readiness (e.g., visits to sick call/ER, limited duty status).
- b. Compare injury incidence between APFT test events (i.e., examine injury incidence in the push-up event and the 2-mile run).
- c. Assess risk factors for acute injury that result from training for APFT events.
- d. Develop effective training regimens that do not train solely for purposes of passing the test events, but act more effectively to improve performance in

- both testing and military tasks, with less potential for acute and chronic injury that might result from repetitively training for test events.
- e. Determine how APFT test results predict potential for injury, task performance, or overall fitness.
 - f. Develop research for assessing cumulative trauma due to repetitive performance of APFT tasks (i.e., run, sit-up, push-up) and how this may relate to future disability costs.

This qualitative assessment of sit-up related injuries reported to the Safety Center reinforces what is known, in a general sense, about sit-up related injury and suggests some hypotheses and research questions that deserve further study.

CONCLUSIONS

The qualitative nature of this study prevents us from drawing definitive conclusions about sit-up related injury in active-duty soldiers. Given the relatively low number of sit-up related injuries retrieved from a database containing reports on hundreds of thousands of lost-time injuries, we cannot conclude that the sit-up event of the APFT poses a significant risk to soldier health. We encourage further research designed to assess the potential risks and benefits that result from testing and training for specific APFT test events.

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APPENDIX A: INSTRUCTIONS FOR SIT-UP APFT EVENT (FM 21-20)

Army FM 21-20. Instructions for Sit-ups

Sit Ups. This event measures the endurance of the abdominal and hip-flexor muscles (See Figure 14-5).

Equipment. One stopwatch is needed along with one clipboard and pen for each scorer. The event supervisor must have the following: the instructions in this chapter on how to conduct the event and one copy of the sit-up scoring standards (DA Form 705).

Facilities. Each station is 6 feet wide and 15 feet deep. Ensure that no more than 15 soldiers are tested at a station. Personnel One event supervisor must be at the test site and one scorer at each station. The event supervisor may not be the event scorer.

Instructions. The event supervisor must read the following: "THE SIT-UP EVENT MEASURES THE ENDURANCE OF THE ABDOMINAL AND HIP-FLEXOR MUSCLES. ON THE COMMAND 'GET SET', ASSUME THE STARTING POSITION BY LYING ON YOUR BACK WITH YOUR KNEES BENT AT A 90-DEGREE ANGLE. YOUR FEET MAY BE TOGETHER OR UP TO 12 INCHES APART. ANOTHER PERSON WILL HOLD YOUR ANKLES WITH THE HANDS ONLY. NO OTHER METHOD OF BRACING OR HOLDING THE FEET IS AUTHORIZED. THE HEEL IS THE ONLY PART OF YOUR FOOT THAT MUST STAY IN CONTACT WITH THE GROUND. YOUR FINGERS MUST BE INTERLOCKED BEHIND YOUR HEAD AND THE BACKS OF YOUR HANDS MUST TOUCH THE GROUND. YOUR ARMS AND ELBOWS NEED NOT TOUCH THE GROUND. ON THE COMMAND 'GO', BEGIN RAISING YOUR UPPER BODY FORWARD TO, OR BEYOND, THE VERTICAL POSITION. THE VERTICAL POSITION MEANS THAT THE BASE OF YOUR NECK IS ABOVE THE BASE OF YOUR SPINE. AFTER YOU HAVE REACHED OR SURPASSED THE VERTICAL POSITION, LOWER YOUR BODY UNTIL THE BOTTOM OF YOUR SHOULDER BLADES TOUCH THE GROUND. YOUR HEAD, HANDS, ARMS, OR ELBOWS DO NOT HAVE TO TOUCH THE GROUND. AT THE END OF EACH REPETITION, THE SCORER WILL STATE THE NUMBER OF SIT-UPS YOU HAVE CORRECTLY COMPLETED. A REPETITION WILL NOT COUNT IF YOU FAIL TO REACH THE VERTICAL POSITION, FAIL TO KEEP YOUR FINGERS INTERLOCKED BEHIND YOUR HEAD, ARCH OR BOW YOUR BACK AND RAISE YOUR BUTTOCKS OFF THE GROUND TO RAISE YOUR UPPER BODY, OR LET YOUR KNEES EXCEED A 90-DEGREE ANGLE. IF A REPETITION DOES NOT COUNT, THE SCORER WILL REPEAT THE NUMBER OF YOUR LAST CORRECTLY PERFORMED SIT-UP. THE UP POSITION IS THE ONLY AUTHORIZED REST POSITION. IF YOU STOP AND REST IN THE DOWN (STARTING) POSITION, THE EVENT WILL BE TERMINATED. AS LONG AS YOU MAKE A CONTINUOUS PHYSICAL EFFORT TO SIT UP, THE EVENT WILL NOT BE TERMINATED. YOU MAY NOT USE YOUR HANDS OR ANY OTHER MEANS TO PULL OR PUSH YOURSELF UP TO THE UP (RESTING) POSITION OR TO HOLD YOURSELF IN THE REST POSITION. IF YOU DO SO, YOUR PERFORMANCE IN THE EVENT WILL BE TERMINATED. CORRECT PERFORMANCE IS IMPORTANT. YOU WILL HAVE TWO MINUTES TO PERFORM AS MANY SIT-UPS AS YOU CAN. WATCH THIS DEMONSTRATION." (The exercise is then demonstrated. See Figure 14-6 for a list of points that need to be made during the demonstration.) "WHAT ARE YOUR QUESTIONS?"

Figure 14-5. Situps

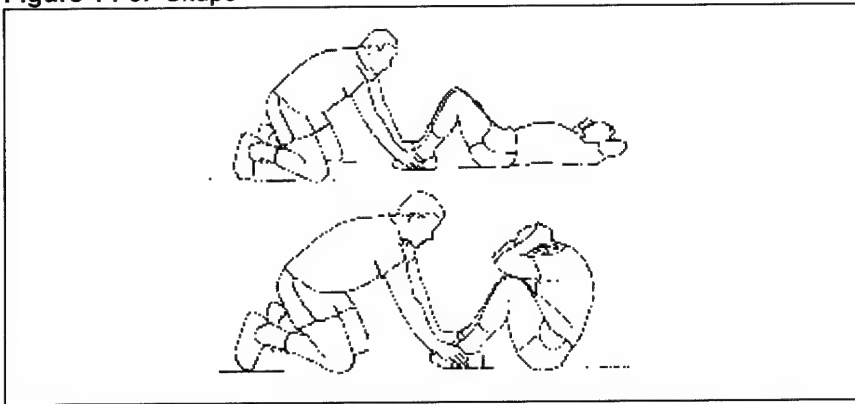


Figure 14-6. Additional Points to Demonstrate for the Sit-Up Event

The following points must be clarified during the demonstration:

- To minimize stress to the neck, it is recommended that the soldier keep his chin curled downward and touching the top of his chest throughout the performance of the sit-up event.
- From the starting (down) position, or during any phase of the sit-up, the soldier may not use his hands or arms to pull himself up to push off the ground (floor or mat) in order to help himself attain the sitting position. Any of these procedures can give the violator an unfair advantage. They also violate the intent of the event. The sit-up event will be terminated immediately for those soldiers who, by pushing or pulling, use their arms to assist themselves in attaining the up position.
- If a mat is used, the entire body, including the feet and head, must be on the mat at the start.
- From the starting (down) position, or during any phase of the sit-up, the soldier may not swing his hands or arms in order to help himself attain the up position. If this occurs, that repetition does not count.
- The soldier may wiggle to attain the up position. This gives him no advantage.
- While in the up position, the soldier may not help himself stay in that position by using the elbows or any part of the arms to lock on to or brace against the legs. The elbows can go either inside or outside the knees. However, to push or pull them into the sides or tops of the knees to get extra leverage and rest gives an unfair advantage to that soldier. Therefore, soldiers who use this technique will be warned once for the first violation and immediately terminated if the violation continues or recurs.
- During the performance of the sit-up event, the fingers must be interlocked and behind the head. As long as any of the fingers are overlapping to any degree, the fingers are considered to be interlocked.
- If either foot breaks contact with the ground during a repetition, that repetition will not count. Both heels must stay in contact with the ground (floor or mat) during the performance of the event. The scorer should ensure that the holder has the soldier's feet properly secured. The scorer tells the soldier if his heel(s) is raised from the ground and that the repetition will not count.

ARMY PHYSICAL FITNESS TEST SCORECARD

6-14-64 7:30 PM 257th St 91 6111 41

DA FORM 706, MAY 63

U.S. ARMY ABBREVIATED GROUND ACCIDENT REPORT (AGAR)										REQUIREMENT CONTROL SYMBOL CSOCS-308																																																																																																																																																																																																																																																																																																																																																					
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1. TIME & DATE OF ACCIDENT		a. Yr	b. Mo	c. Day	d. Time	2. PERIOD OF DAY		Day	Night	3. ACC CLASS		4. ACC OCCURRED DURING:		5. UNIT IDENTIFICATION		6. UIC (6-digit Code)		7. EXPLOSIVES/AMMO		8. PRESENT		9. YES		10. INVOLVED		11. TYPE LOCATION		12. COMBAT		13. COMBAT		14. COMBAT		15. COMBAT		16. COMBAT		17. COMBAT		18. COMBAT		19. COMBAT		20. COMBAT		21. COMBAT		22. COMBAT		23. COMBAT		24. COMBAT		25. COMBAT		26. COMBAT		27. COMBAT		28. COMBAT		29. COMBAT		30. COMBAT		31. COMBAT		32. COMBAT		33. COMBAT		34. COMBAT		35. COMBAT		36. COMBAT		37. COMBAT		38. COMBAT		39. COMBAT		40. COMBAT		41. COMBAT		42. COMBAT		43. COMBAT		44. COMBAT		45. COMBAT		46. COMBAT		47. COMBAT		48. COMBAT		49. COMBAT		50. COMBAT		51. COMBAT		52. COMBAT		53. COMBAT		54. COMBAT		55. COMBAT		56. COMBAT		57. COMBAT		58. COMBAT		59. COMBAT		60. COMBAT		61. COMBAT		62. COMBAT		63. COMBAT		64. COMBAT		65. COMBAT		66. COMBAT		67. COMBAT		68. COMBAT		69. COMBAT		70. COMBAT		71. COMBAT		72. COMBAT		73. COMBAT		74. COMBAT		75. COMBAT		76. COMBAT		77. COMBAT		78. COMBAT		79. COMBAT		80. COMBAT		81. COMBAT		82. COMBAT		83. COMBAT		84. COMBAT		85. COMBAT		86. COMBAT		87. COMBAT		88. COMBAT		89. COMBAT		90. COMBAT		91. COMBAT		92. COMBAT		93. COMBAT		94. COMBAT		95. COMBAT		96. COMBAT		97. COMBAT		98. COMBAT		99. COMBAT		100. COMBAT																																																																																																																																																			
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37. WHY WAS THE MISTAKE MADE (ROOT CAUSE) (Check the root cause(s) in Bk a. In Bk b. tell how the root cause(s) led to the mistake.)									
LEADER	TRAINING	STDS/PROCEDURES	SUPPORT	INDIVIDUAL					
(Not ready, waiting at entrance supervised)	(Qualification)	(Participation/No practice)	(Overcoming in type capability, amount or condition of equip, supplies, services, facilities)	(Mistake due to own actions/ errors)					
Direct Supervisor	School	AR	AR	Poor Bad attitude					
Unit: Command Supervisor	Unit:	FM	FM	Overconfidence					
Higher Command Supervisor	Experience, O-2	FM	FM	Alcohol, Drugs					
				In a hurry					
b. Describe root cause(s) (reasons) and tell how it/they caused the mistake				38. ENVIRONMENTAL CONDITIONS					
				a. Present:					
				#1 <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unk					
				#2 <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unk					
				#3 <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unk					

38. PROVIDE BRIEF SYNOPSIS OF ACD (Use additional sheets if required/English sequence of events, tell how event happened.)

40. CORRECTIVE ACTION(S) TAKEN OR PLANNED

41. POINT OF CONTACT FOR INFORMATION ON THE ACCIDENT			
a. Name (Last, First, MI)	b. Telephone #	DSN:	
		COM:	
42. COMMAND REVIEW a. Name		b. Date	
b. Signature	c. Rank	43. SAFETY OFFICE REVIEW	
	d. Date	a. Name	

REVERSE OF DA FORM 285-AB-R, JUL 94

APPENDIX D: SAMPLE SAFETY CENTER NARRATIVE REPORTS

Following are a sample of text narratives from the Safety Center reports regarding injuries deemed to be sit-up related.

1. WHILE DURING THE SIT-UP PART OF THE APFT, SM STRAINED HIS BACK. (6316 PERFORMING APFT)
2. DURING PT TEST- PULLED BACK MUSCLES DOING SITUPS.
3. WHILE DOING AN APFT TEST PULLED GROIN. (4863 AFPT SITUPS)
4. DURING PT, SOLDIER WAS GOING SIT UPS AND SPRAINED HER RIGHT HIP.
5. AT APPROX 1330 HRS, 8 NOV 76, PV1 JON DOE WAS PERFORMING SIT UPS IN A PT TEST AND DISLOCATED HIS SHOULDER. NEITHER DRUGS NOR ALCOHOL WERE INVOLVED. NO PROTECTIVE EQUIPMENT WAS BEING USED. WEATHER WAS NOT A CONTRIBUTING FACTOR.
6. WHILE DOING SIT-UPS ON AN ANNUAL PHYSICAL FITNESS TEST (APFT) HE HEARD A SNAP AND FELT A SHARP PAIN IN HIS LOWER BACK. HE THEN STOPPED AND WAS HELPED TO THE SIDE WHERE HE COMPLAINED OF REAL BAD PAIN IN HIS LOWER BACK AT WHICH TIME HE WAS TAKEN TO THE HOSPITAL. (7361 DOING SIT-UPS ON A PHYSICAL FITNESS TEST)
7. ON 7 APRIL 1990, AT 1000 HOURS PFC JON DOE WAS TAKING THE ARMY PHYSICAL FITNESS TEST. HE WAS IN THE PROCESS OF DOING THE SIT-UP PORTION OF THE TEST WHEN THE MAT HE WAS LYING ON MOVED DUE TO HIS BODY MOVEMENT. AFTER HE COMPLETED HIS SIT-UPS HE NOTICED HE HAD PAIN IN HIS LOWER BACK. HE THEN LYED DOWN ON A TABLE UNTIL MEDICAL PERSONNEL ARRIVED. (*6181 DOING SIT-UPS WHILE TAKING PT TEST)
8. NO INDICATION OF ALCOHOL/DRUG INVOLVEMENT. PV2 JON DOE WAS TAKING HIS FINAL APFT PRIOR TO GRADUATION FROM HIS MOS TRAINING. WHILE HE WAS BEING GRADED ON THE SIT-UP PORTION OF HIS TEST, HIS HEAD STRUCK THE HEAD OF AN UNIDENTIFIED SOLDIER WHILE HE WAS ON THE WAY DOWN TO THE GROUND TO COMPLETE A REPETITION OF THE SIT UP. PV2 JON DOE COMPLETED THE ENTIRE APFT, & PASSED. THE NEXT DAY HE FELT HIS VISION BLUR & COMPLAINED OF FAINTING & NUMBNESS ON HIS LEFT SIDE OF HIS BODY. HE WENT TO THE EMERGENCY ROOM AND WAS ADMITTED FOR A CONCUSSION & OBSERVATION.

9. SM WS PERFORMING SIT-UPS AS PART OF INDIVIDUAL P.T. IN MORNING. AS HE GOT TO HIS CAR TO LEAVE THE GYM, HE FELT PAIN IN HIS LOWER BACK AND LEG. HE HAD FELT HIS BACK SORE DURING EXERCISE AND CESASED PROLONGING SIT-UPS. HE FELT HE HAD ONLY OVERWORKED THE MUSCLES IN HIS BACK.HE REPORTED TO SICKCALL ON 28 APRIL 1994 AND RECEIVED PAIN KILLERS AND A PROFILE. REPORTED AGAIN FOR EMERGENCY SICK CALL ON 1 MAY 1994. ADMITTED TO HOSPITAL FROM 31 MAY TO 14 JUNE 1004. CURRENTLY ON CONVALESCENT LEAVE. (3714 PHYSICAL FITNESS TRAINING/SIT-UPS)
10. AT APPROX 0040 HRS. WHILE WORKING A MID-SHIFT (2130-0530) SPC JANE DOE WAS CONDUCTING PT IN THE WEIGHT ROOM. SHE WAS DOING INCLINE SITUPS WITH A 10 LB WEIGHT FOR ADDED RESISTANCE WHEN SHE FELT A SLIGHT PAIN IN HER LOWER BACK. PROBABLY A MUSCLE STRAIN DUE TO OVER-CONFIDENCE IN HER OWN ABILITIES. SHE WENT TO THE EMERGENCY ROOM WHERE SHE WAS TREATED FOR A STRAINED MUSCLE IN HER LOWER BACK AND GIVEN A PROFILE FOR 7 DAYS. (8355 INCLINE SITUPS ON INCLINE BENCH WITH A 10 LB WEIGHT AS ADDED RESISTANCE)